Source-to-Sink in the Stratigraphic Record

Capturing the Long-Term, Deep-Time Evolution of Sedimentary Systems

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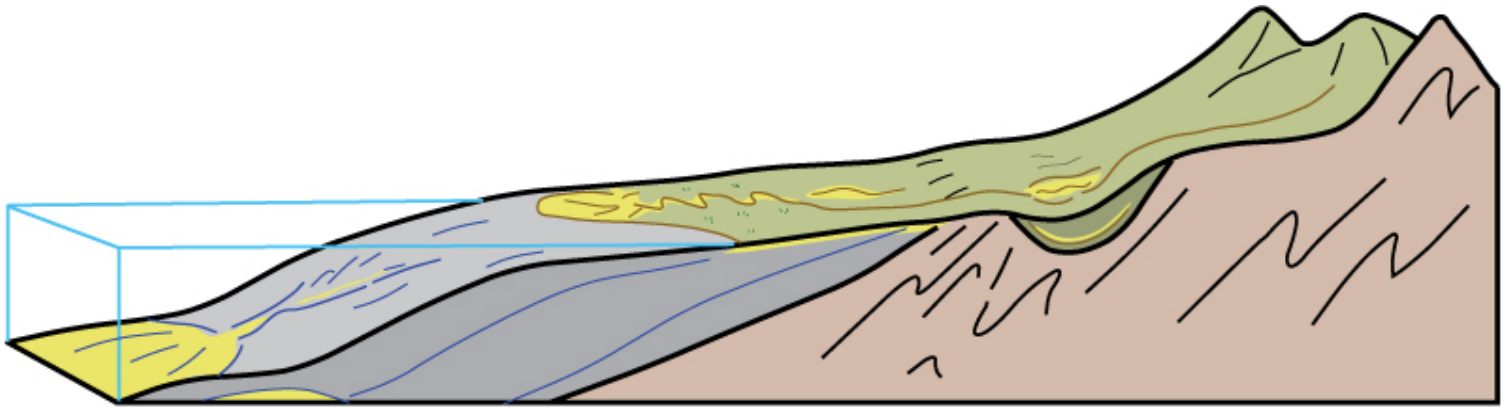
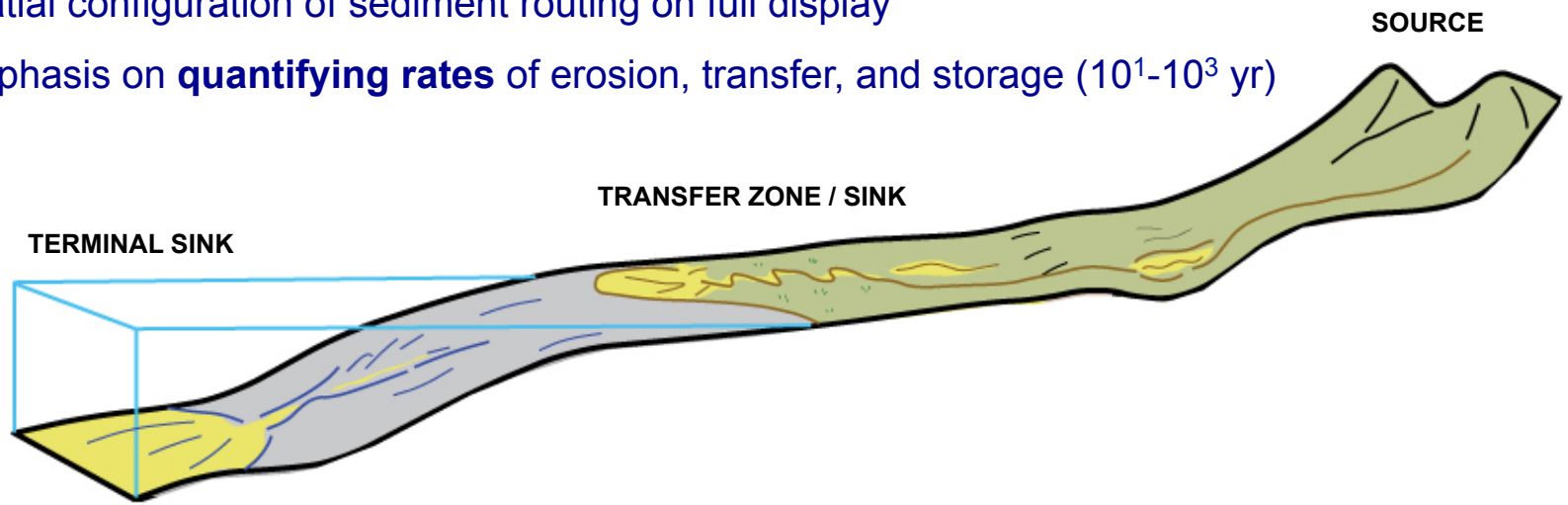


Source-to-Sink in Deep Time

- spatial and temporal resolution diminished, but long-term (>10^4 yr) landscape evolution can be evaluated
- stratigraphic surfaces vs. geomorphic surfaces -- paleogeographic reconstructions are time-averaged representations of landscapes
- sources lost to erosion over long time scales, but integrated analysis (with new technologies) can address the nature of long-gone landscapes
- when sink becomes source (S2S2S …); tectonic recycling especially relevant in foreland basin systems
- applying insights from LGM-to-present S2S studies to ancient

Source-to-Sink at 'Time Zero'

- production and transport of sediment in net-erosional source areas
- transfer of mass to net-depositional sinks (sedimentary basins)
- spatial configuration of sediment routing on full display
- emphasis on **quantifying rates** of erosion, transfer, and storage (10^1-10^3 yr)

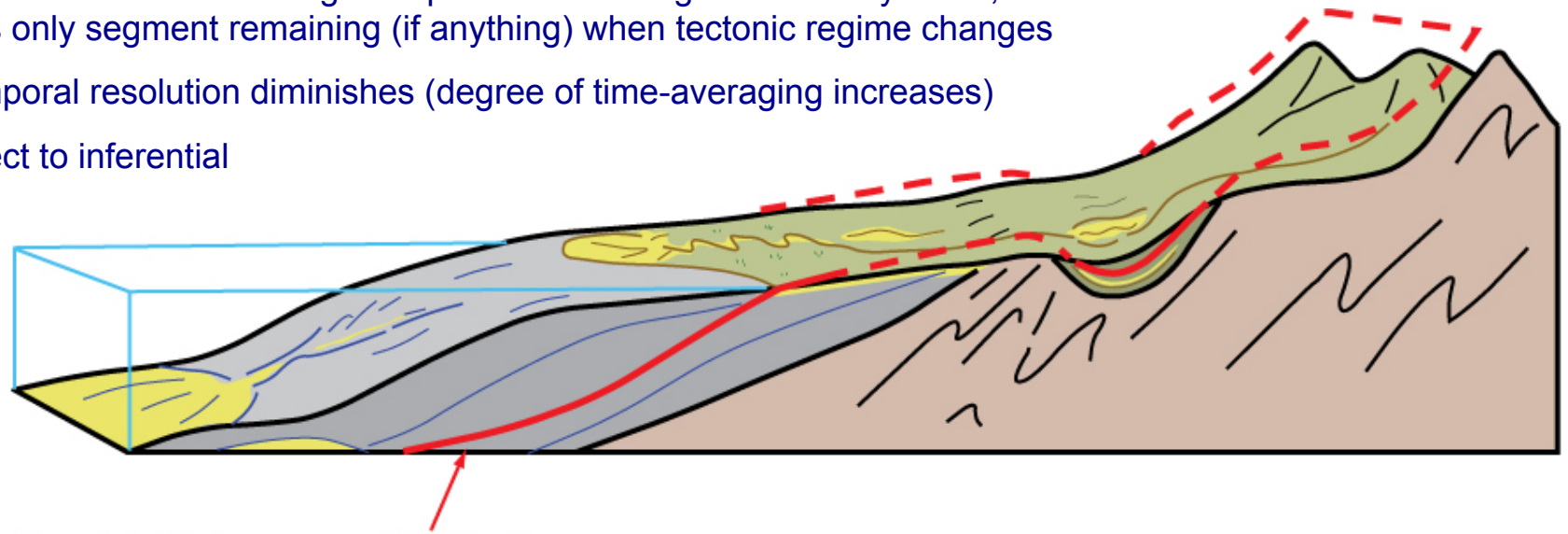


S2S at time zero permits robust investigation of forcings: climatic fluctuation, sea-level changes, oceanographic conditions, tectonics (activity/geometry), etc.

Source-to-Sink in Deep Time

As We Scroll Back Through Geologic Time …

- source area modified; removed completely as mass is transferred
- sinks in transfer zone might be preserved in long-lived S2S systems; terminal sinks only segment remaining (if anything) when tectonic regime changes
- temporal resolution diminishes (degree of time-averaging increases)
- direct to inferential



Chronostratigraphic (Paleogeographic) Surface

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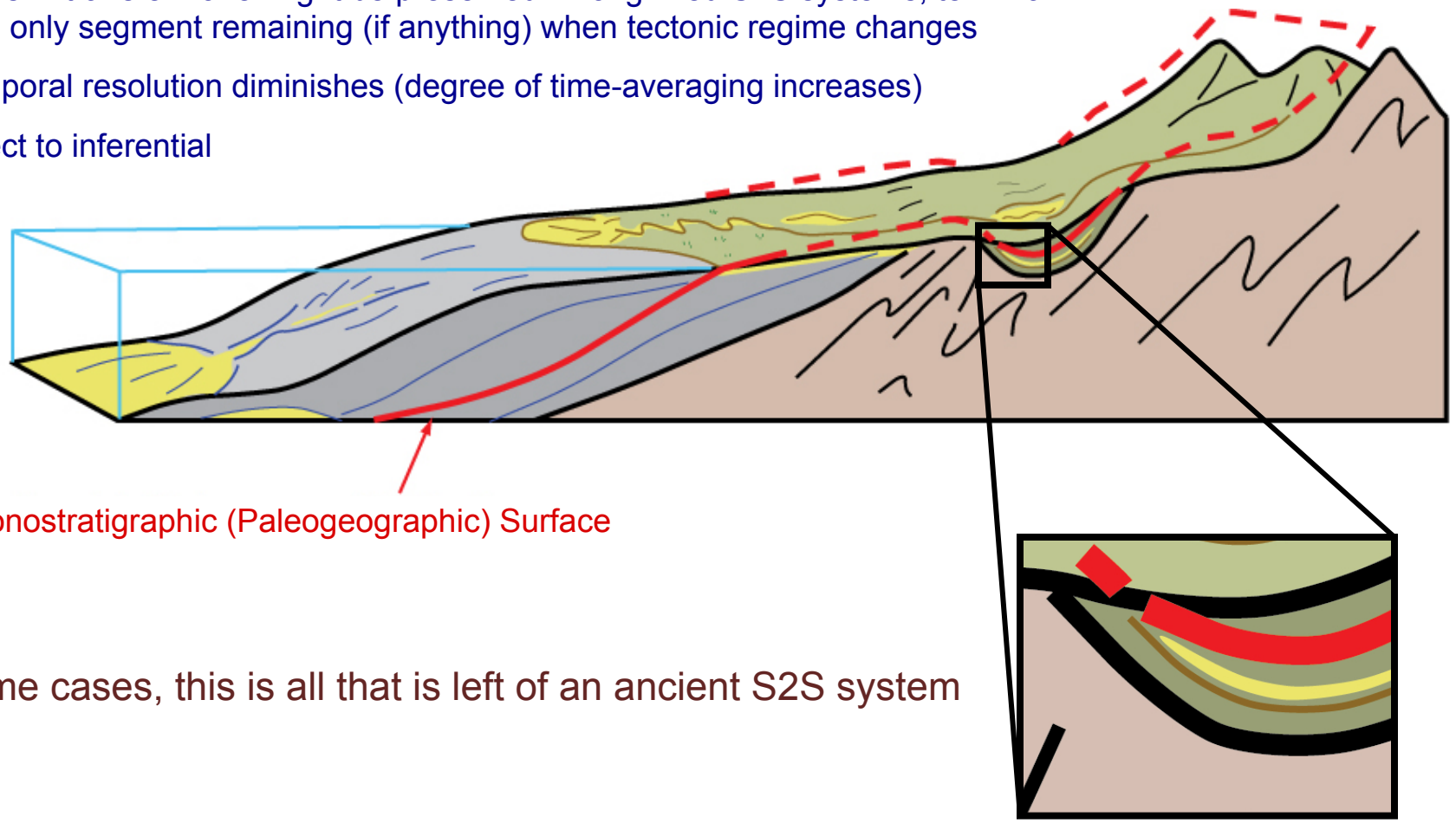

In some cases, this is all that is left of an ancient S2S system

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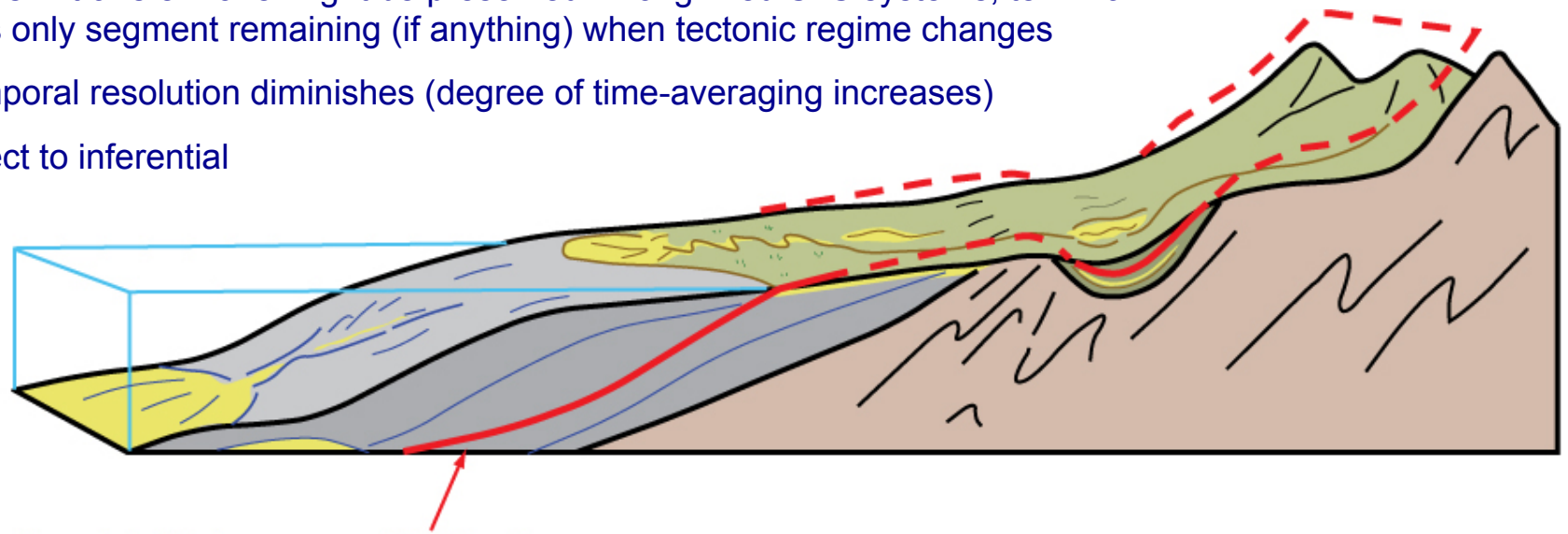
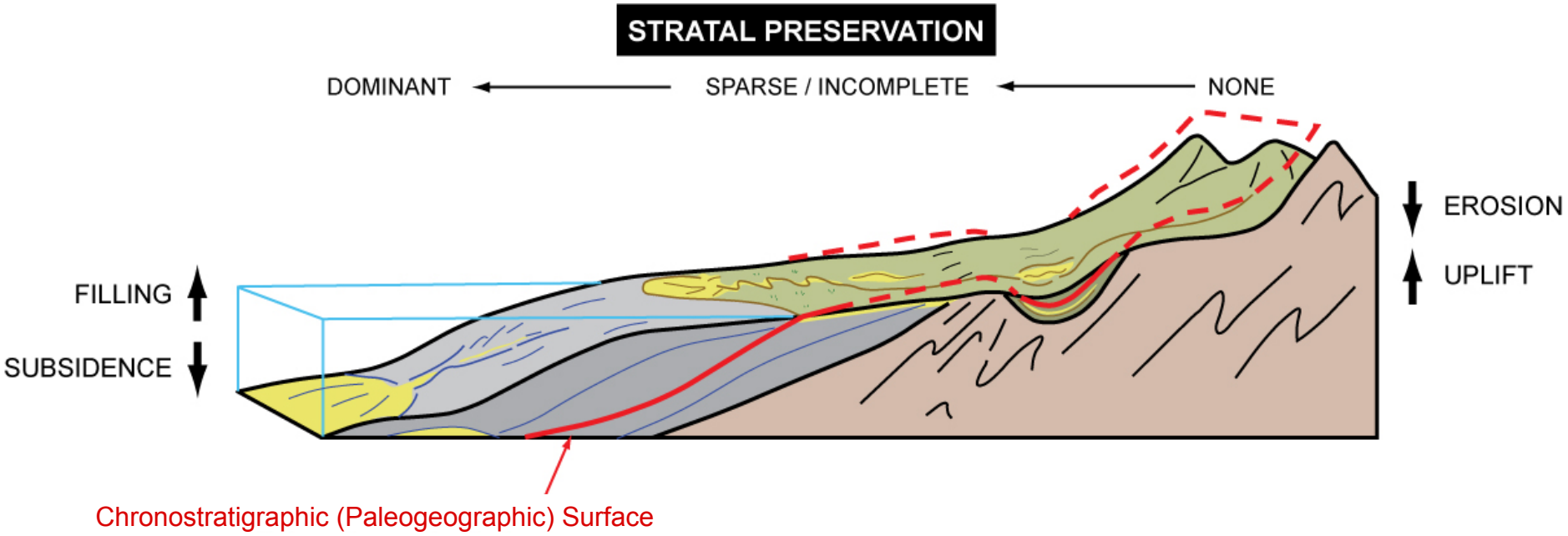


Chronostratigraphic (Paleogeographic) Surface

But … the opportunity to document **long-term landscape evolution** exists only in the deep-time record

Source-to-Sink in Deep Time -- Preservation

Cartoon depicts a long-lived (>10s m.y.) S2S system along a basin margin (prior to significant tectonic regime change). Increasing preservation potential from source to transfer zone to terminal sinks.



Source-to-Sink in Deep Time -- Preservation & Approaches

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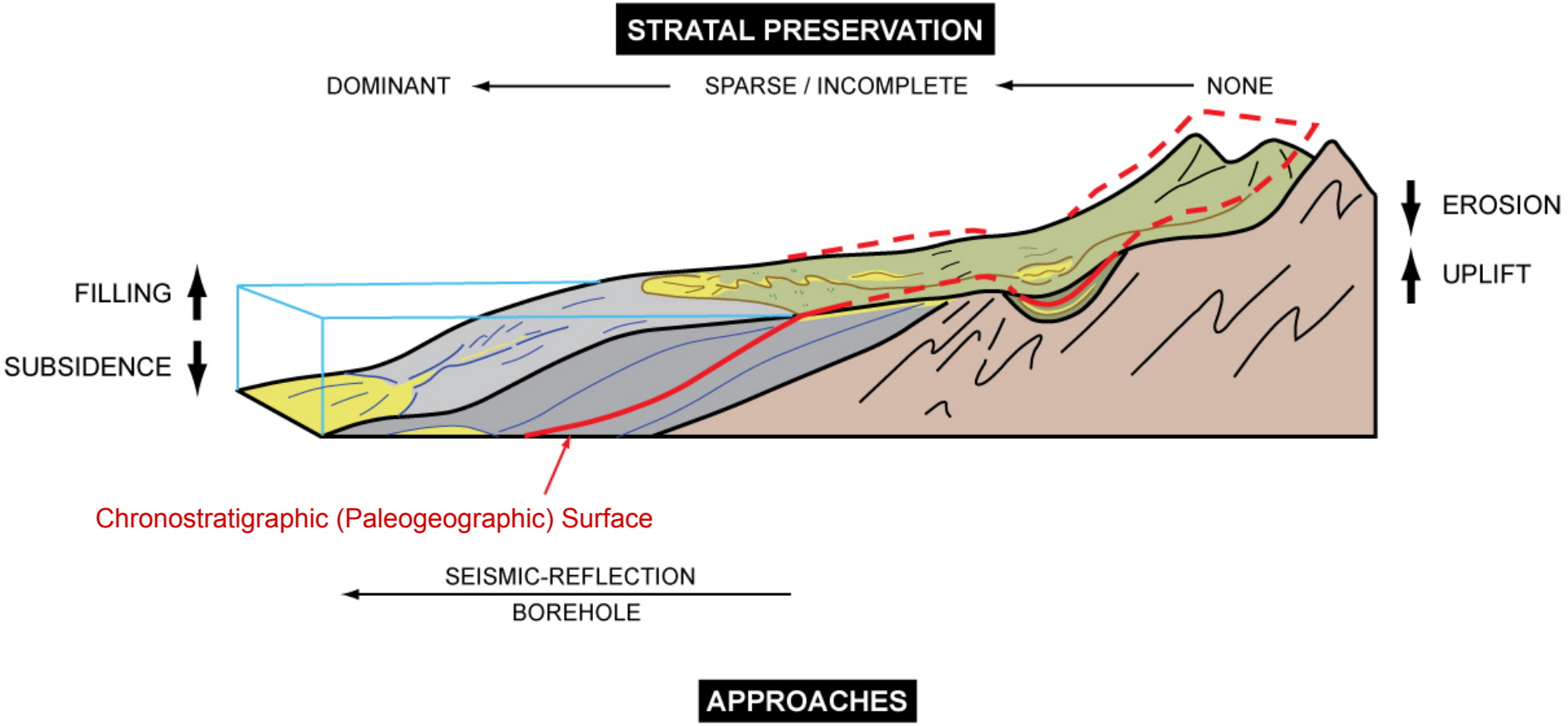
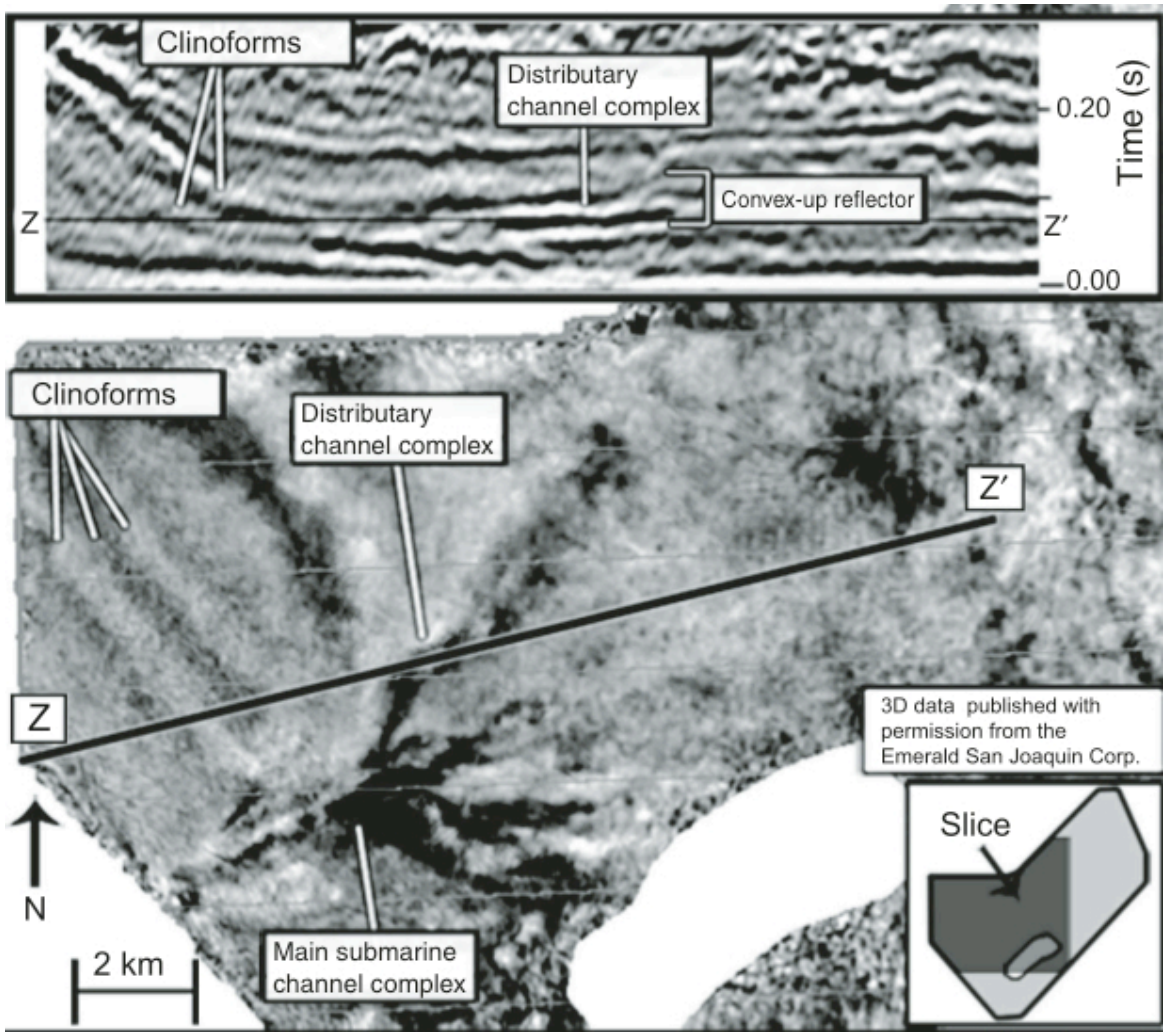


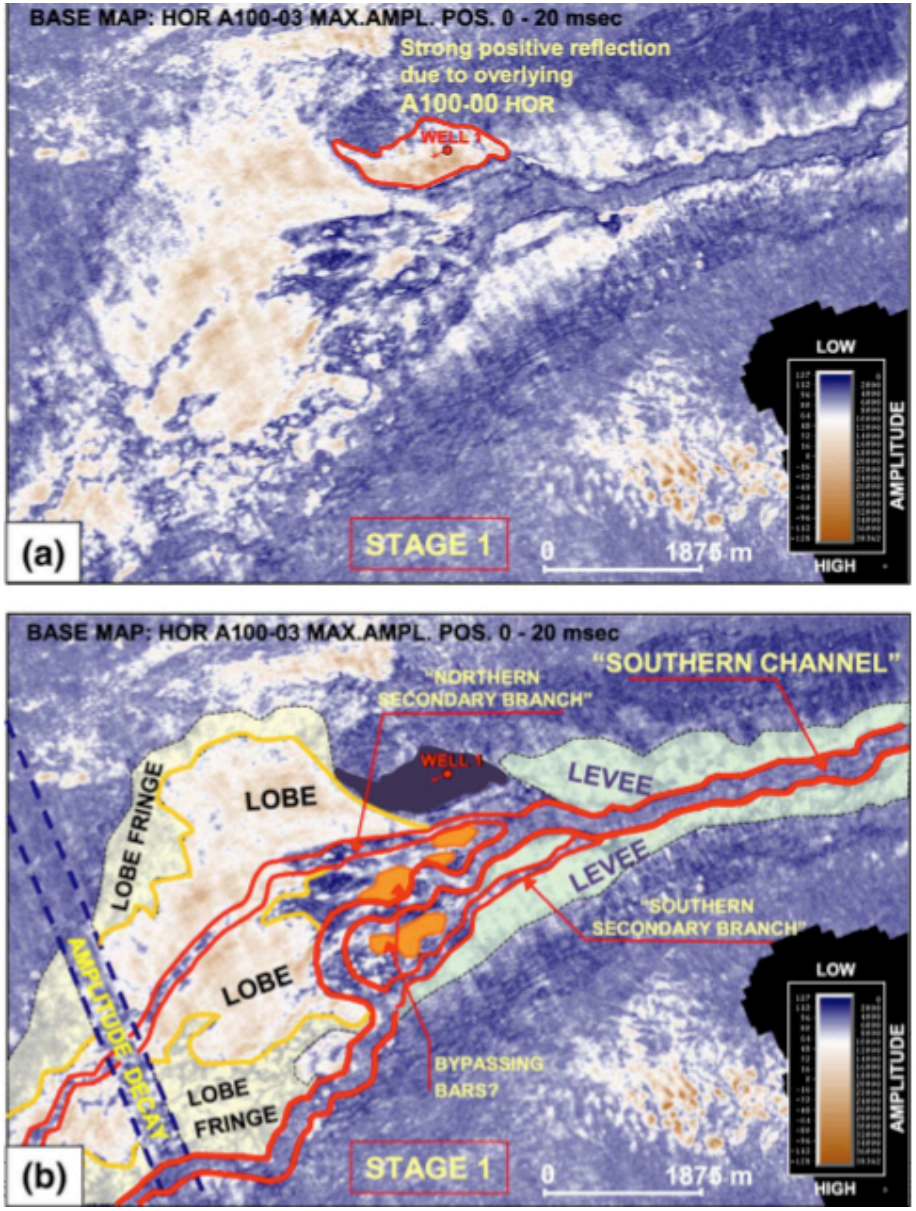
Sediment-Routing Configuration in Stratigraphic Record



Mitchell et al. (2009)

3D seismic-reflection has allowed us to slice through stratigraphy in map view

Sediment-Routing Configuration in Stratigraphic Record



Fonnesu (2003)

We are beginning to analyze the morphology of these time-averaged landscapes more quantitatively

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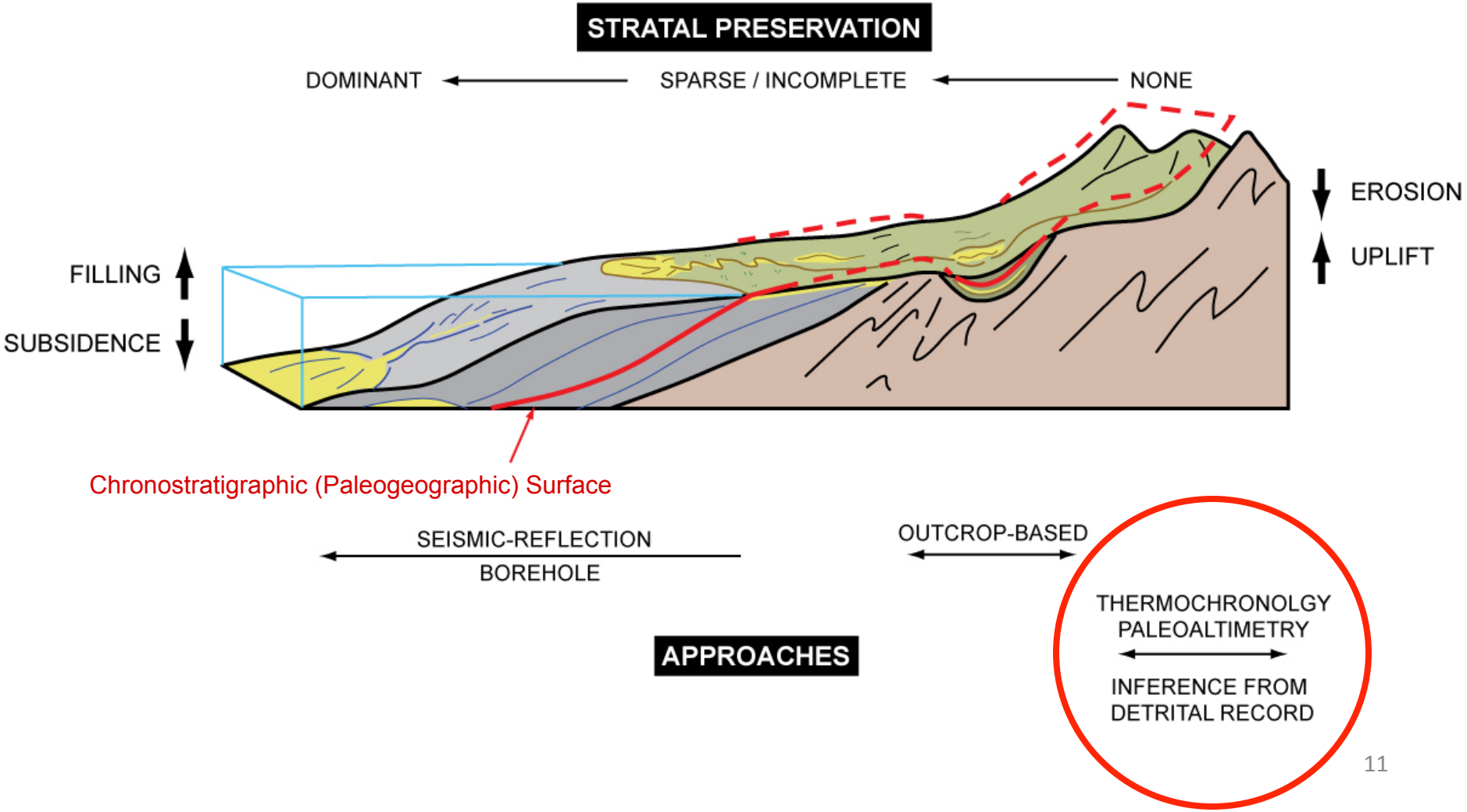
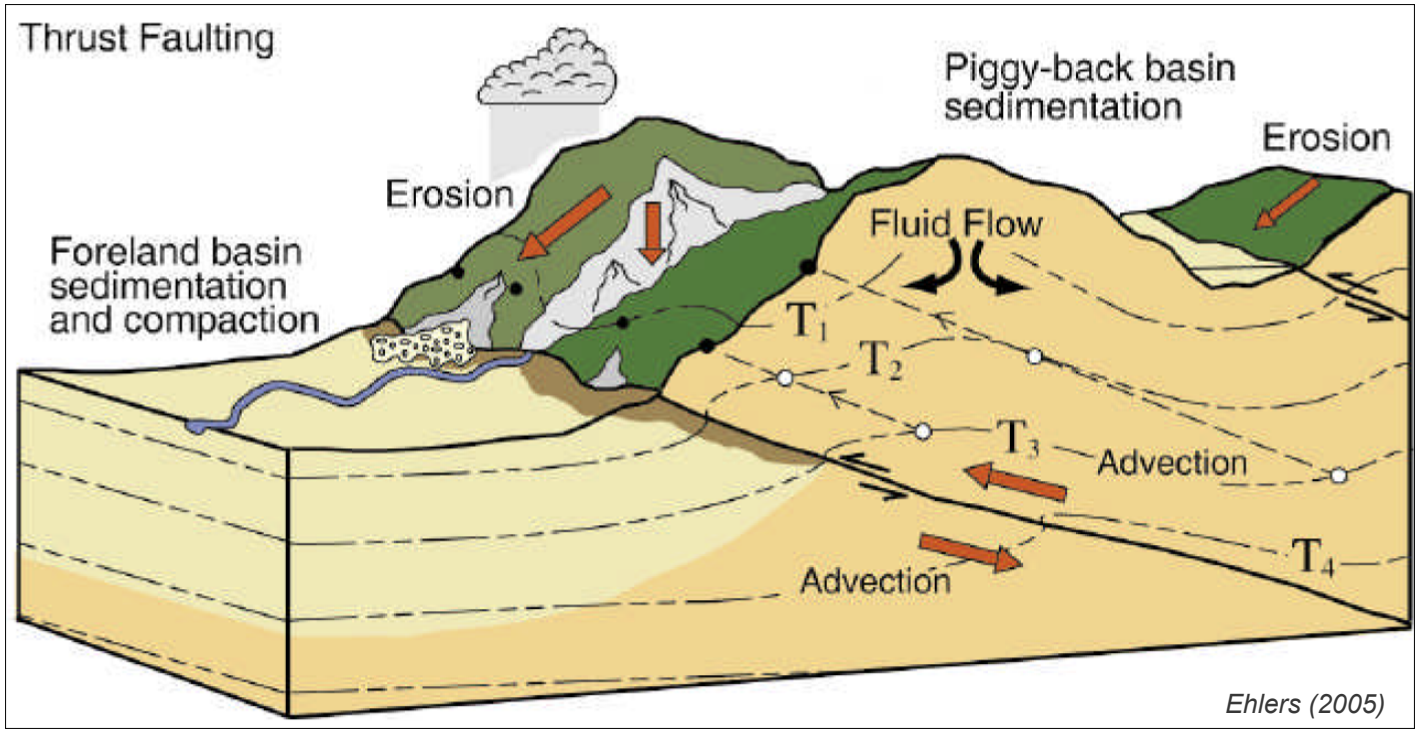


Long-Term Landscape Evolution -- Exhumation

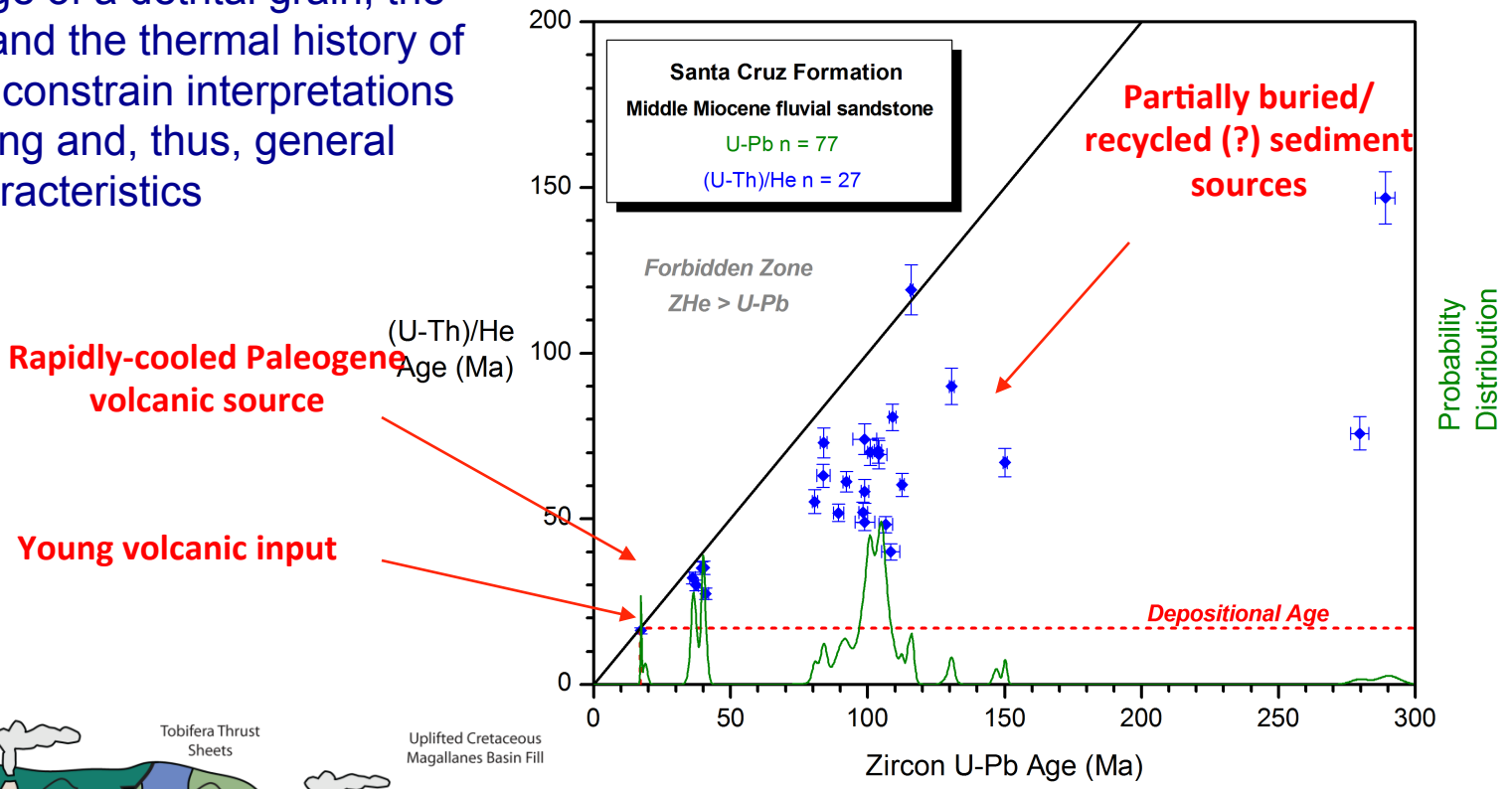
Thermochronology uses the fossil record of heat flow to determine rates of exhumation.

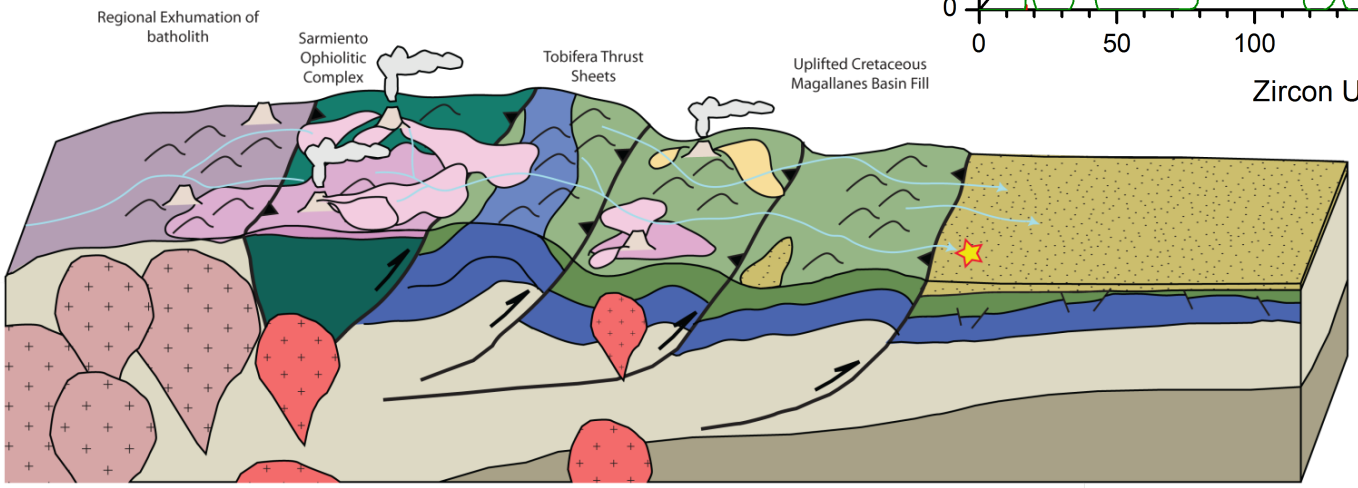


Long-Term Landscape Evolution -- Exhumation

Determining the age of a detrital grain, the depositional age, and the thermal history of the grain can help constrain interpretations of exhumation timing and, thus, general source-to-sink characteristics

Fosidick et al. (in prep)



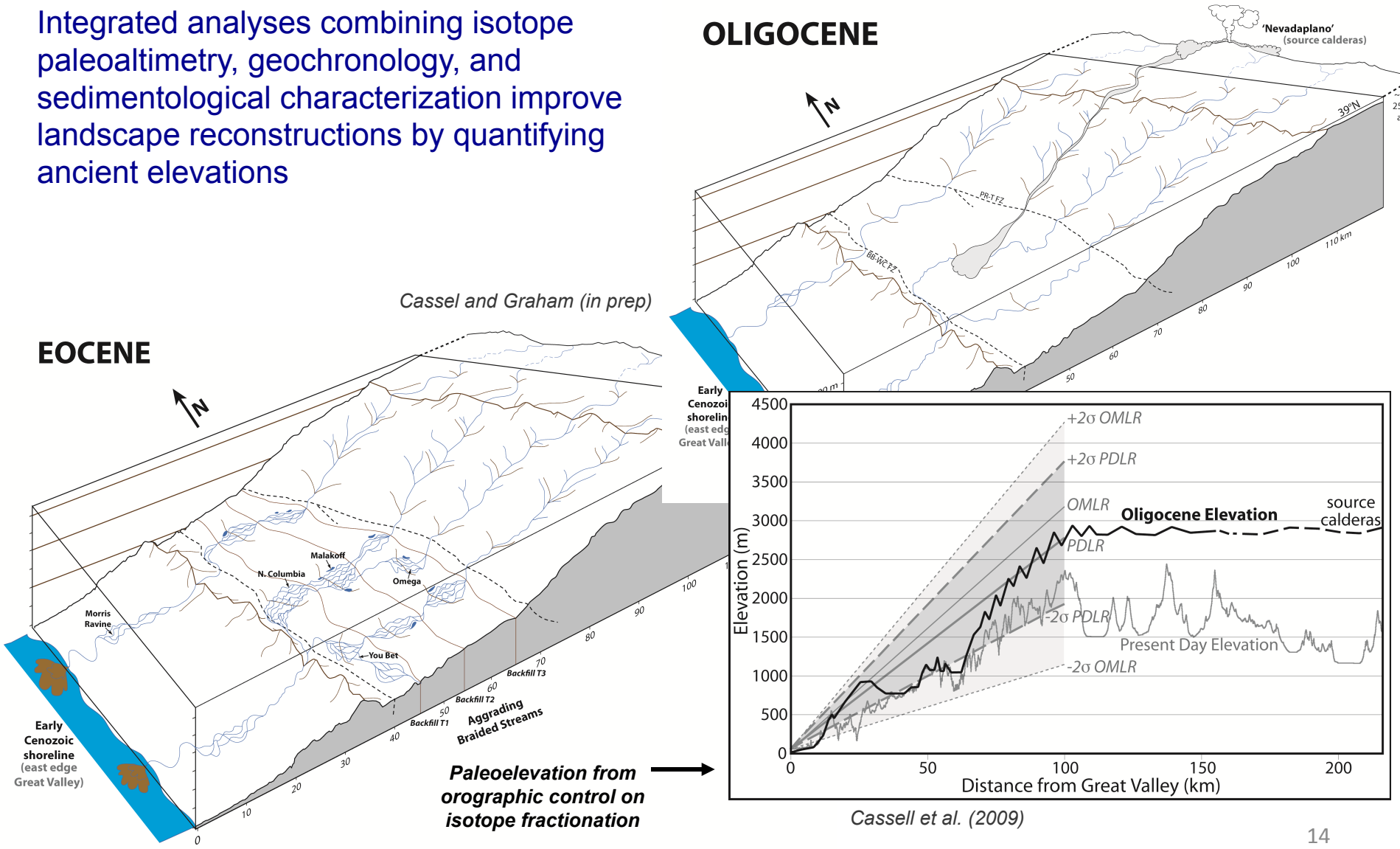


Coupled U-Pb-He Detrital Thermochronology

Zircon (U-Th)/He T_c ~ 170-190°C

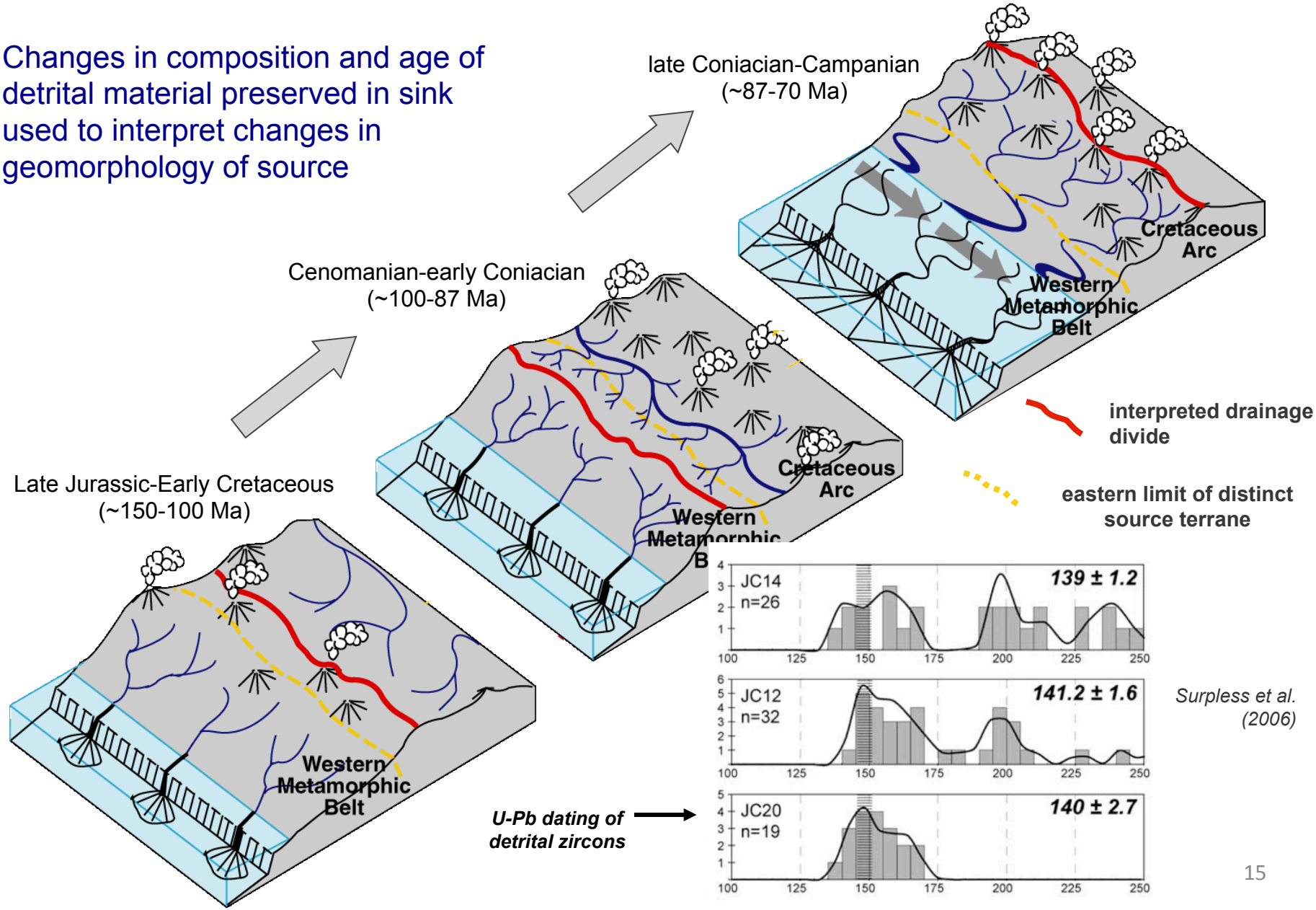
Long-Term Landscape Evolution -- Changes in Elevation

Integrated analyses combining isotope paleoaltimetry, geochronology, and sedimentological characterization improve landscape reconstructions by quantifying ancient elevations



Long-Term Landscape Evolution -- Changes in Drainage Divide

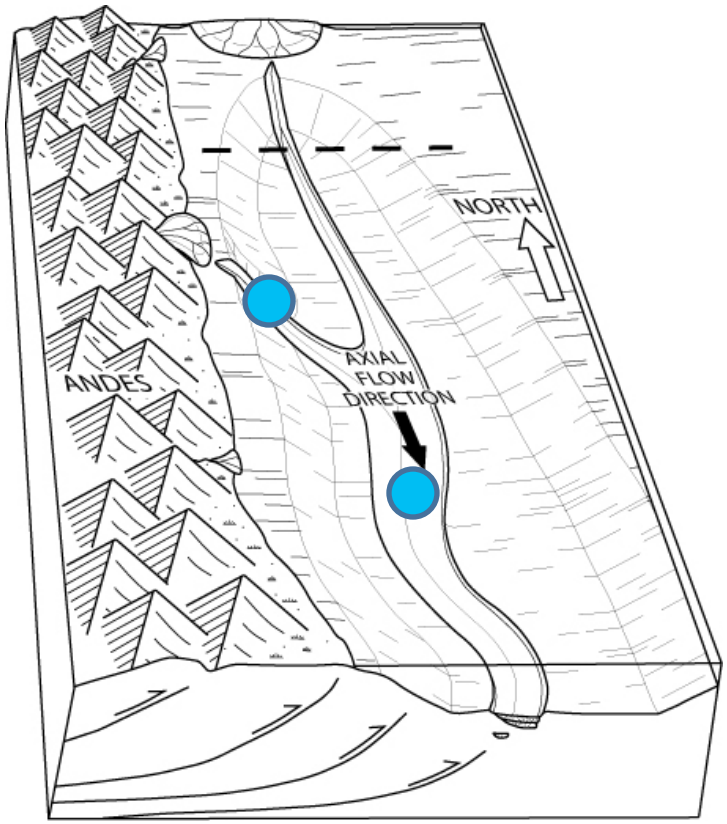
Changes in composition and age of detrital material preserved in sink used to interpret changes in geomorphology of source



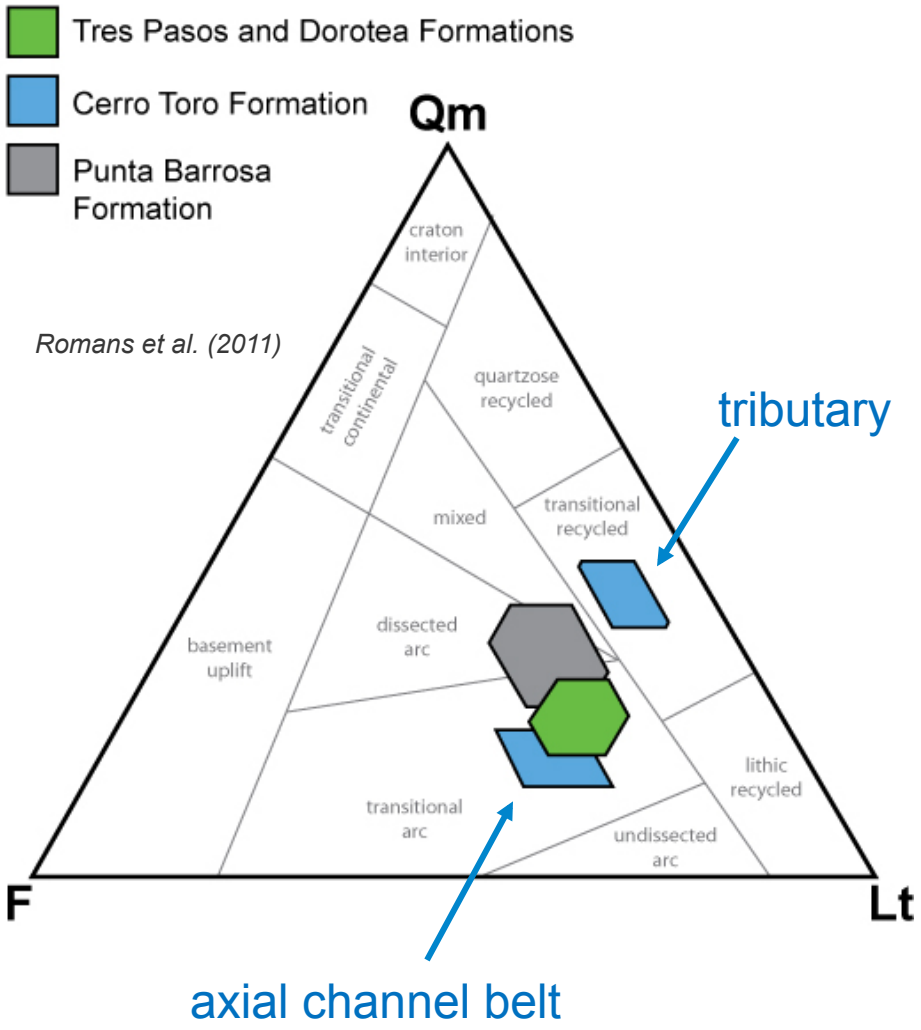
Surpless et al. (2006)

Long-Term Landscape Evolution -- Sediment Routing

Sandstone composition, especially when combined with detailed strat characterization and other provenance methods, can provide insights into sediment-routing configuration.

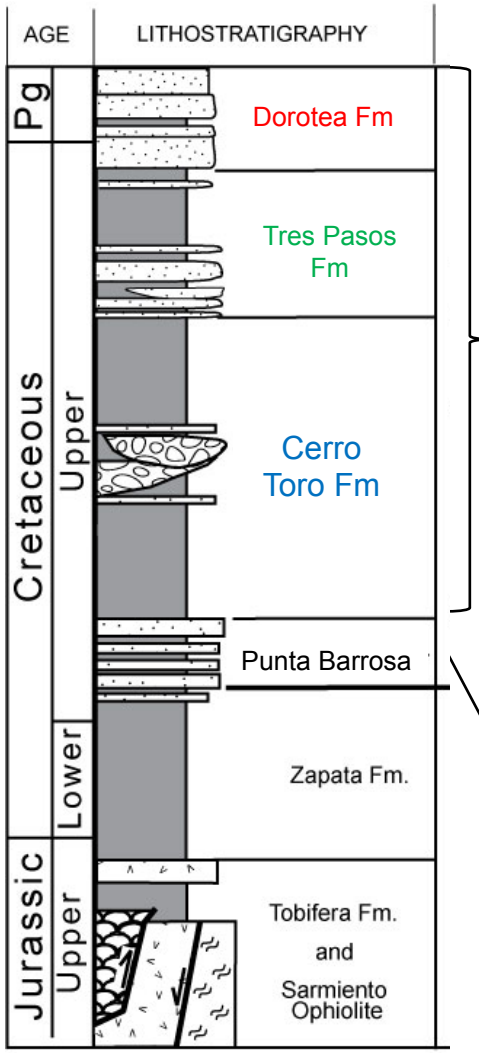


Hubbard et al. (2008)



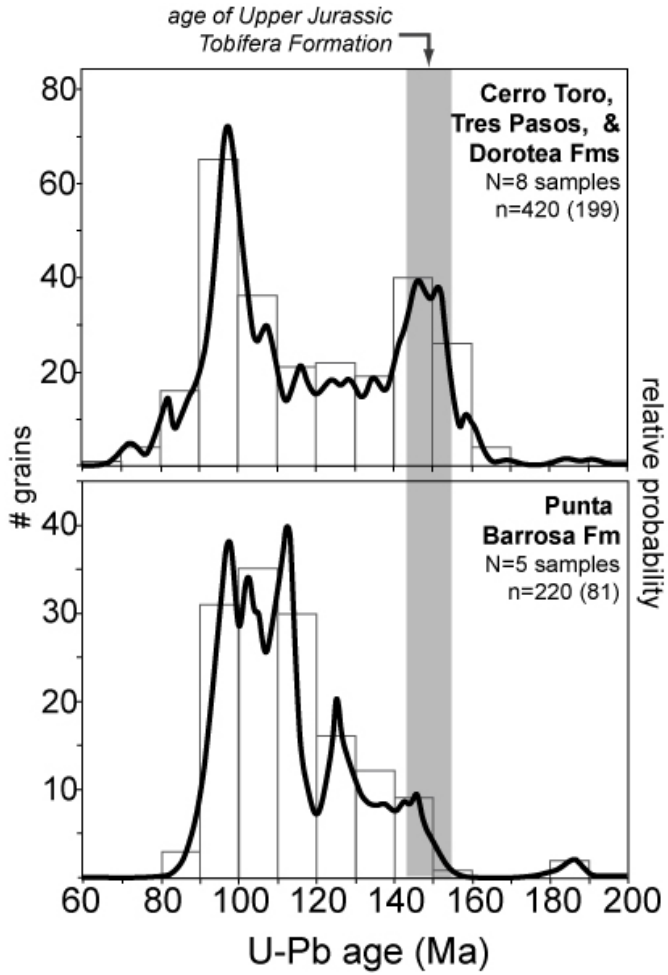
Romans et al. (2011)

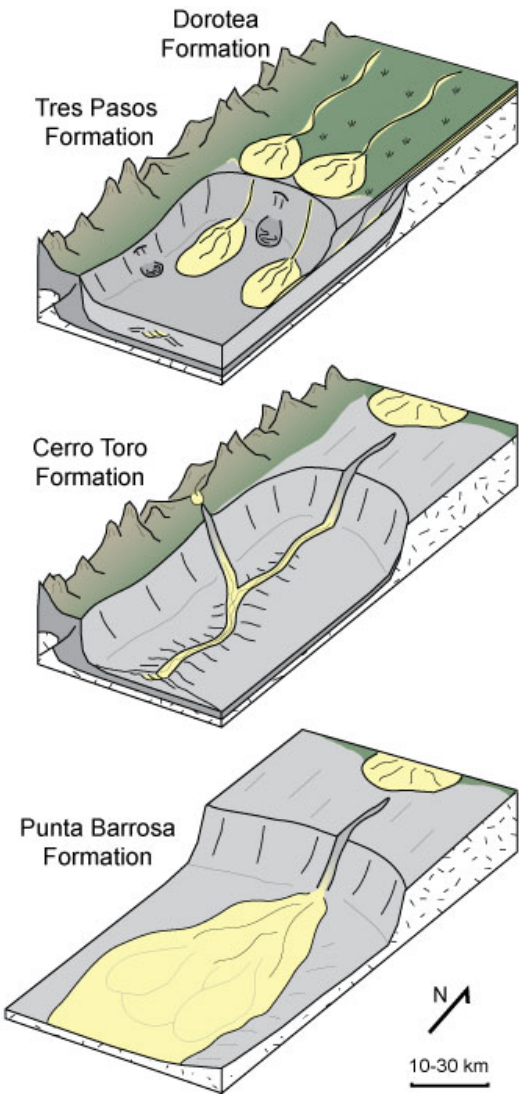
Long-Term Landscape Evolution -- Source Area Proximity & Basin Configuration



Romans et al. (2011)

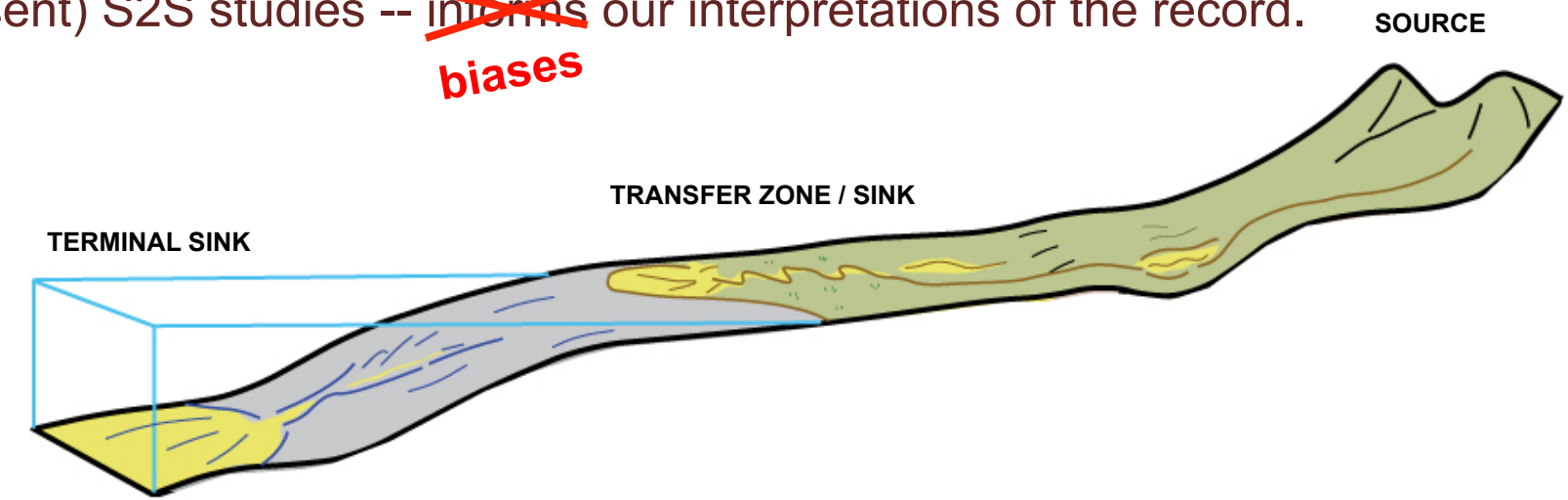
Detrital zircons constrain timing of thrust sheet emplacement -- introduction of gravel to basin and significant change in shape





Quaternary S2S as Analog for Deep Time

Information about sediment routing pathways, fluxes between segments, and forcings -- as derived from modern (LGM-present) S2S studies -- ~~informs~~ **biases** our interpretations of the record.

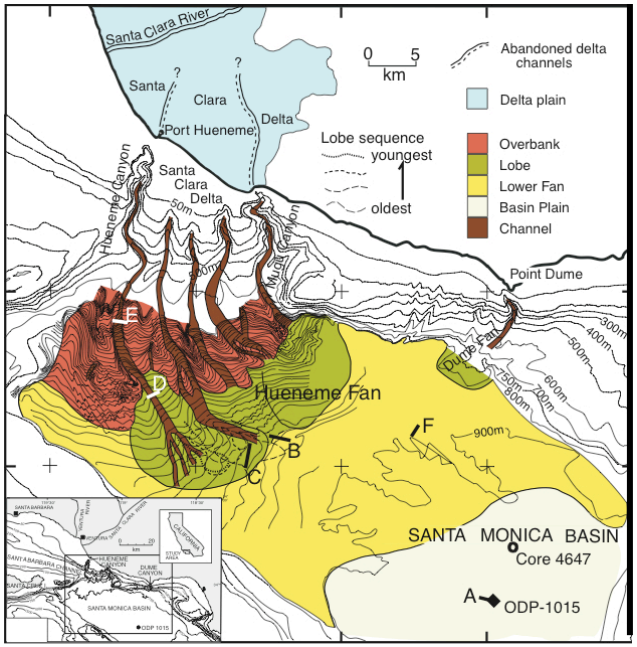


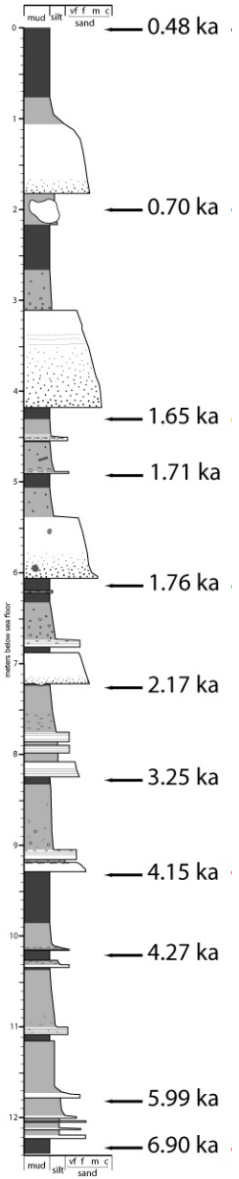
Questions about whether the modern snapshot of Earth's S2S systems are important -- Should we compare only to other highstand times? Should we compare only to other icehouse times? Etc.

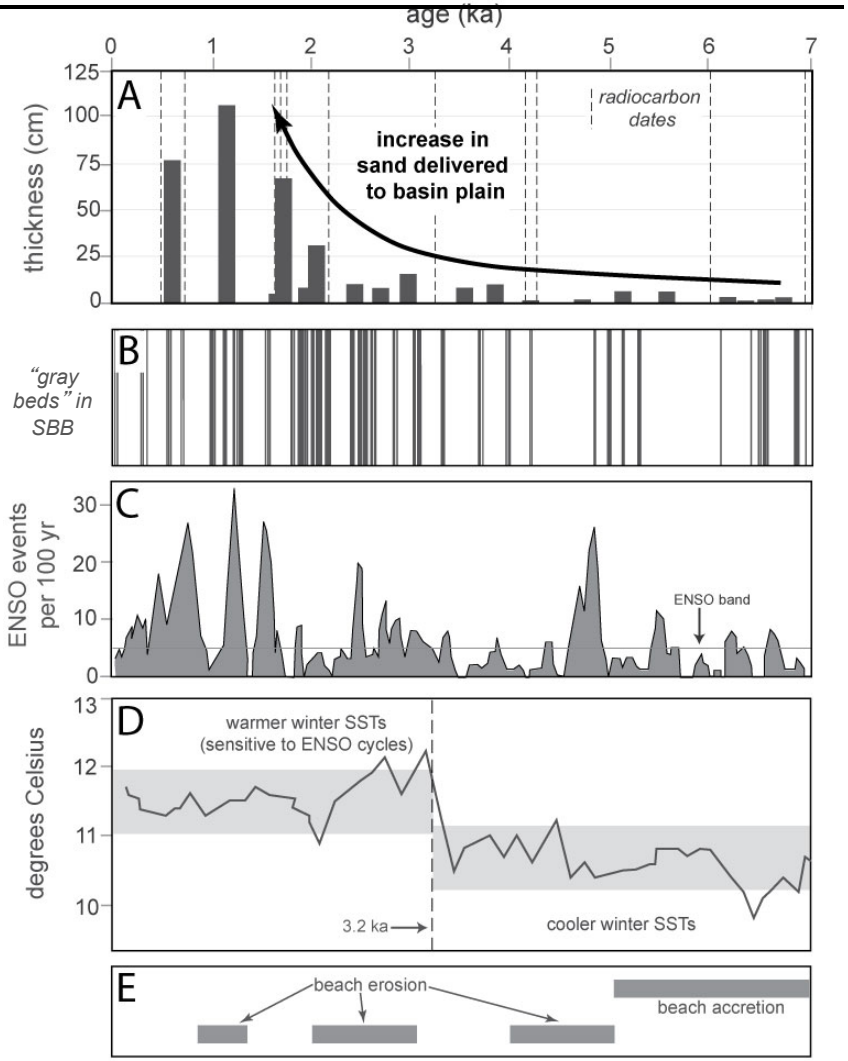
Insights from Quaternary S2S Studies

Investigation of frequency/magnitude of sedimentation events that build stratigraphy leads to questions:

How does depositional morphology (and thus preserved strat architecture) vary as a function these relationships?

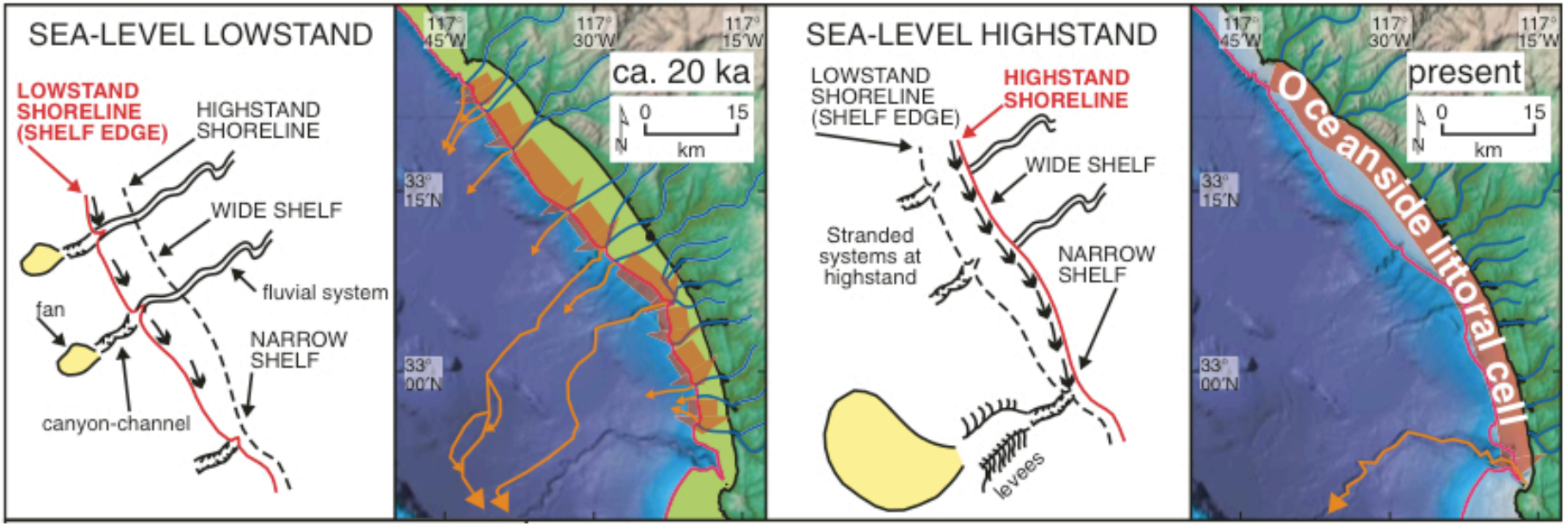






Romans et al. (2009)

Insights from Quaternary S2S Studies

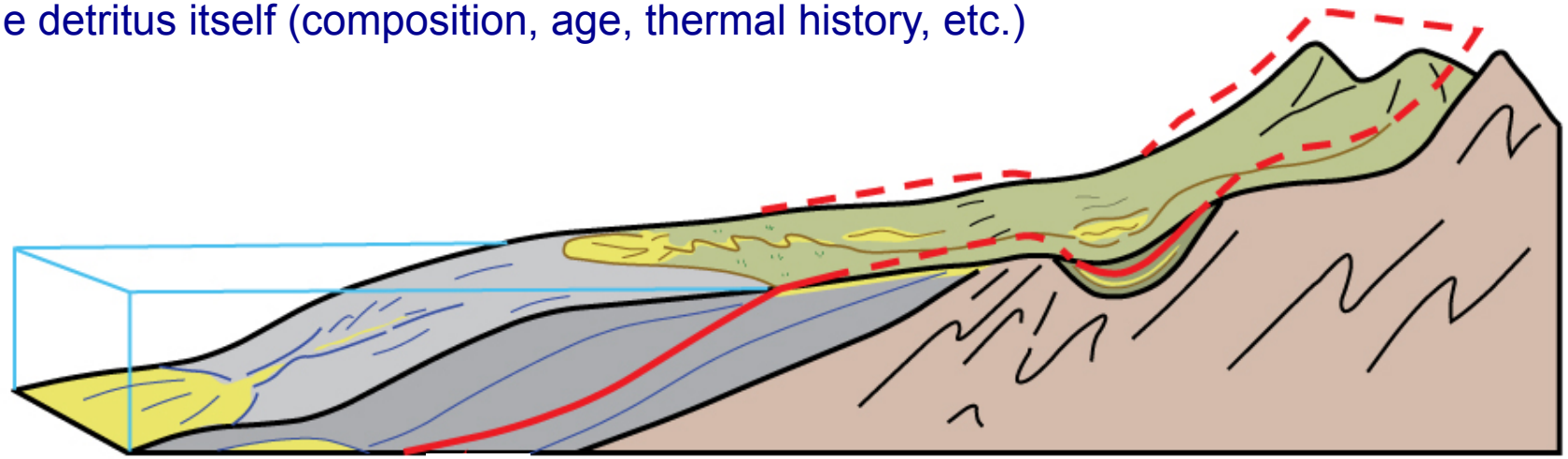


Covault et al. (2007)

Quaternary S2S systems can be used to improve one of our main tools for interpreting the deep-time record -- **conceptual models**.

Source-to-Sink in Deep Time

Paleo-S2S investigation requires combining analysis of how the detritus piled up (stratigraphic characterization) **AND** the nature of the detritus itself (composition, age, thermal history, etc.)



Concepts about signal transfer/propagation, material fluxes at different timescales, influence of episodicity/intermittency, etc. coming from the S2S community are changing the way we think about the development of the stratigraphic record.